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मानक

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IS 15519 (2004): Water mist fire protection systems -
Systems design, installation and commissioning - Code of
practice [CED 22: Fire Fighting]



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Bhartrhari—Nitiśatakam

“Knowledge is such a treasure which cannot be stolen”

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भारतीय मानक

वाटर मिस्ट अग्नि सुरक्षा पद्धतियाँ — पद्धति डिजाइन,
संस्थापन और चालू करना — रीति संहिता

Indian Standard

WATER MIST FIRE PROTECTION
SYSTEMS — SYSTEM DESIGN, INSTALLATION
AND COMMISSIONING — CODE OF PRACTICE

ICS 13.220.10

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BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Fire Fighting Sectional Committee had been approved by the Civil Engineering Division Council.

The fire protection of a building or plant must be considered as a whole. While water mist fire protection systems form only a part, though an important one, of the available facilities, it should not be assumed that their adoption necessarily removes the need to consider supplementary measures, such as the provision of portable fire extinguishers or mobile appliances for first aid or emergency use or measures to deal with special hazards.

Water mist systems have been found to be effective for the suppression or extinguishment of a wide variety of exposed and shielded Class B hydrocarbon pool fires and for combinations of incidental Class A and Class B fires. Water mist systems have also demonstrated their effectiveness on some Class A fires, including insulated electrical cable fires.

This standard is not intended to be a substitute for sprinkler systems, which provide similar or equivalent performance to water mist protection.

For the purpose of deciding whether a particular requirements of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

WATER MIST FIRE PROTECTION SYSTEMS — SYSTEM DESIGN, INSTALLATION AND COMMISSIONING — CODE OF PRACTICE

1 SCOPE

1.1 This standard lays down minimum requirements for design, installation and commissioning of water mist fire protection systems using potable water.

1.2 Sea water may be used in installations like ships. When sea water is used system shall be flushed after each application.

2 REFERENCES

The standards listed at Annex A contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreement based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards given at Annex A.

3 GENERAL

3.1 The standard is limited to systems that have demonstrated acceptable levels of performance in fire tests as part of a testing process. They may be arranged as total flooding, zoned or local application systems and designed for suppression or extinguishment.

This standard establishes minimum requirements for water mist fire protection technology and is based on sound engineering principles, test data and field experience.

Water mist systems are specialized fire protection systems. Design and installation of these systems requires specialized training, knowledge and experience.

For systems using additives, the requirements of 3 and 12 shall apply.

Water mist fire protection systems are herein referred to as a system or the system.

3.2 This standard addresses the use of fine water sprays for the efficient extinguishment of fires. Water mist systems may be effective on several classes of fire and various applications within those classes, provided they have been tested for the particular application and class.

3.3 Classification Based on Working Pressure

3.3.1 Low Pressure Water Mist System

A water mist system where the distribution piping is subjected to pressure of 1.2 MPa or less.

3.3.2 Intermediate Pressure Water Mist System

A water mist system where the distribution piping is subjected to pressure greater than 1.2 MPa but less than 3.5 MPa.

3.3.3 High Pressure Water Mist System

A water mist system where the distribution piping is subjected to the pressure of 3.5 MPa or greater.

3.4 Classification Based on Type of Fuel

Overall fire hazard is directly related to the type and quantity of the fuel present in a space. The ease of ignition/reignition of the fuel, the fire growth rate, and the difficulty of achieving control, suppression, extinguishment, or any combination thereof, shall be considered when selecting or designing a water mist system.

3.4.1 Class A Fires

Fuel loading and configuration shall be considered when selecting/designing a system to protect a space or area containing Class A materials. If fire extinguishment is desired, consideration shall be given to the potential for deep-seated fires as well as to the potential for smoldering fires.

3.4.2 Class B Fires

The hazard associated with Class B fires is related primarily to the fuel loading, fuel configuration, flashpoint and burning rate of the fuel. Preburn time also affects the overall characteristics of the fire. Class B fires are grouped into two categories — Two-dimensional pool fires and three-dimensional spray and running fuel fires. The parameters associated with each category are as follows:

- a) Class B Two-dimensional fires:
 - 1) Fuel loading and configuration;
 - 2) Fuel flashpoint; and
 - 3) Preburn time pool/spill size.

b) Class B Three-dimensional fires:

- 1) Fuel loading and configuration,
- 2) Fuel flashpoint,
- 3) Preburn time,
- 4) Cascade/running fuel fires,
- 5) Fuel flow rate,
- 6) Fire configuration,
- 7) Spray fires,
- 8) Fuel line pressure,
- 9) Fuel spray angle,
- 10) Fuel spray orientation, and
- 11) Reignition sources.

When designing and installing water mist systems to protect Class B hazards, the parameters specified in 3.4.2(a) and (b) shall be considered.

3.4.3 Class C Fires

Electrical conductivity of water and water mist shall be addressed when considering applications where the primary fire is a Class C fire.

3.4.4 Combination Fires

Combinations in fuel loadings and hazards shall be addressed.

3.5 Classification Based on Type of Fluid**3.5.1 Single Fluid System**, Based on water.**3.5.2 Twin Fluid System**

A water mist system in which water and atomization media (air/ nitrogen) are separately supplied to and mixed at water mist nozzles.

3.6 Classification Based on Particle Size Distribution

As a means of allowing distinctions to be made between coarser and finer sprays across the 1 000 μm spectrum of this standard's definition of water mist, it is useful to subdivide mist into Class 1, 2 or 3 water mist, according to the droplet size distribution. The defining boundaries for the three classifications are illustrated in Fig. 1.

3.6.1 Class 1 Water Mist

The cumulative percent volume distribution curve lies entirely to the left of a line connection $Dv_{10} = 100 \mu\text{m}$ and $Dv_{90} = 200 \mu\text{m}$. This represents the finest water mist.

3.6.2 Class 2 Water Mist

A portion of the cumulative percent volume distribution curve lies beyond the limits of a Class 1

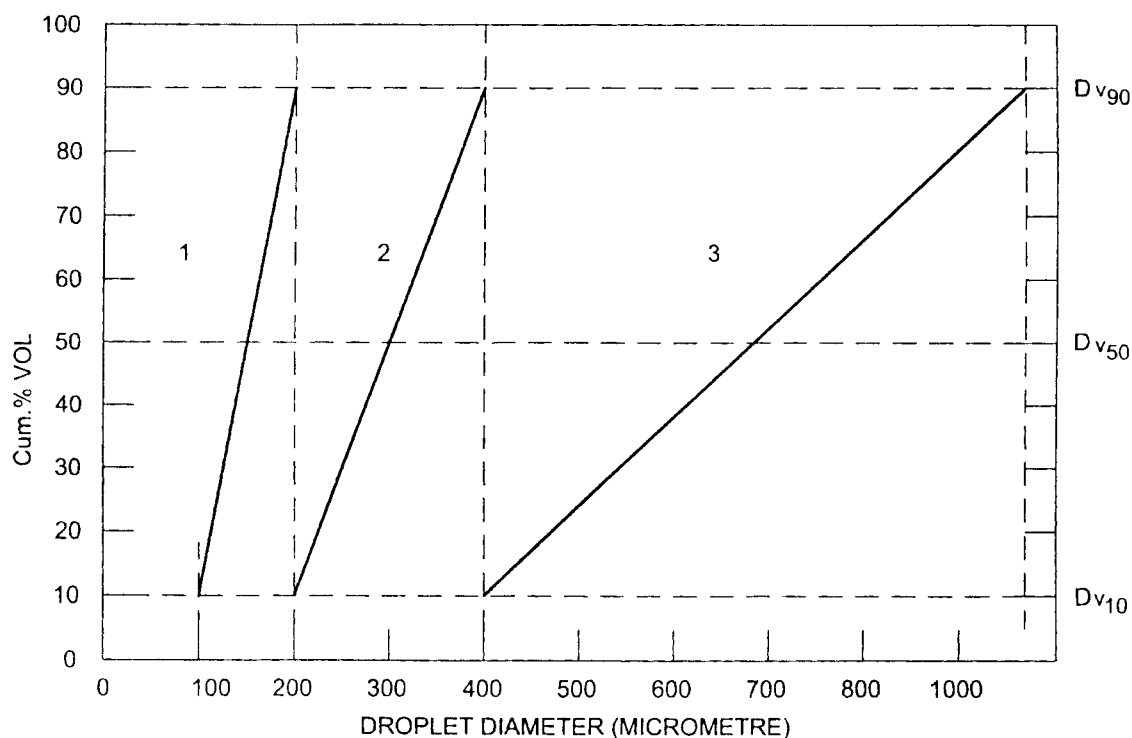


FIG. 1 CLASSIFICATION OF WATER MIST ACCORDING TO DROPLET SIZE

spray, but entirely to the left of the line connecting $Dv_{90} = 200 \mu\text{m}$ and $Dv_{90} = 400 \mu\text{m}$.

3.6.3 Class 3 Water Mist

The Dv_{90} is greater than $400 \mu\text{m}$ or for which any portion of the curve extends to the right of the Class 2 cut-off line (but the Dv_{90} is less than $1\,000 \mu\text{m}$).

3.7 The drop size distribution of a spray does not uniquely define its suitability for a given application. It is inseparable from the spray direction relative to the fire plume, its velocity and flux density. The momentum of an element of spray is the product of its velocity (which includes direction as well as speed) and the mass of dispersed water droplets.

Therefore, all three variables, that is, drop size distribution, flux density and momentum are involved in determining the ability to extinguish a fire in a given scenario.

3.8 Water mist systems offer potential benefits for many specialized applications, particularly when available water supplies are limited or when the application of water must be restricted. Potential benefits may also exist for applications previously protected by gaseous and other specialized fire suppressant system or extinguishing agents.

3.9 A water mist system is a fire protection system using very fine water sprays (that is water mist). The very small water droplets allow the water mist to suppress or extinguish fires by cooling the flame and fire plume, oxygen displacement by water vapour and radiant heat attenuation.

Due to the presence of larger drops, higher mass flow rates are earlier to achieve with Class 2 sprays than with Class 1 sprays. The larger drops are not so large as to be ineffective on liquid fuel fires. However, considerable surface wetting occurs with sprays in this range; therefore a Class 2 mist is also likely to be effective on fires involving ordinary combustibles. Class 3 water mists are typically generated by intermediate pressure, small orifice sprinklers, impingement nozzles of various sorts and fire hose fognozzles.

3.10 System Types

A water mist distribution system is a system that is connected to a water supply and equipped with one or more nozzles capable of delivering water mist. A water mist system shall meet the performance requirements of its intended application.

3.10.1 Pre-engineered Systems

A water mist system having predetermined flow

rates, nozzle pressures and volumes and spray densities of water mist. These systems have the specific pipe sizes, maximum and minimum pipe lengths, flexible hose, number of fittings and number and types of nozzles (see Fig. 2).

3.10.2 Engineered System

A water mist system where, as required by the accepting authority, individual calculation and design shall be done to determine the system flow rates, pipe sizes, area or volume protected by the system, discharge density of water mist, number and types of nozzles and nozzle placement.

3.10.3 Deluge System

A water mist system using nozzles attached to a piping system that are connected to a water supply through a valve and where all nozzles discharge simultaneously (see Fig. 3).

3.10.4 Dry System

A water mist system using sealed nozzles attached to a piping system containing air, nitrogen or inert gas under pressure, the release of which (as from an opening of sealed nozzle) allows the water supply pressure to open a dry-pipe valve. The water then flows into the piping system and out through any nozzles that have opened.

3.10.5 Preaction System

A water mist system using sealed nozzles attached to a piping system containing air that might or might not be under pressure, with a supplemental detection system installed in the same areas as the mist nozzles. The actuation of the detection system opens a valve and the water then flows into the piping system and out through any nozzles that have opened.

3.10.6 Wet System

A water mist system using sealed nozzles attached to a piping system containing water and connected to a water supply so that water discharges immediately from nozzles that are operated by the heat from a fire.

3.10.7 Total Flooding System

A water mist system designed to discharge water mist to simultaneously protect all hazards in an enclosure.

3.10.8 Local Application System

A water mist system arranged to discharge directly on an object or hazard.

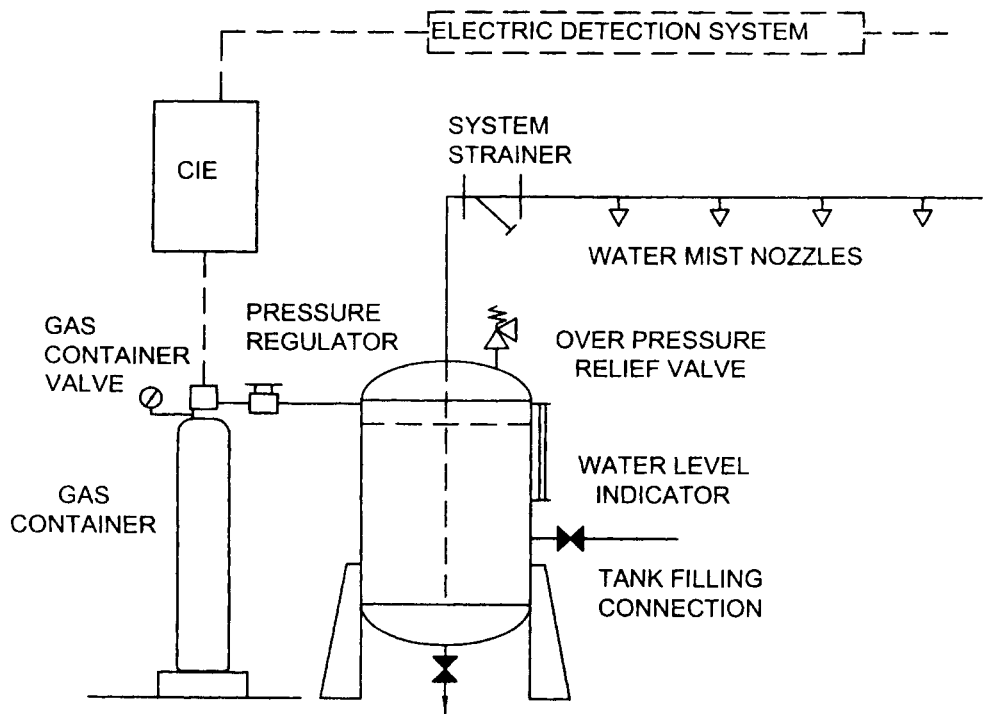


FIG. 2 TYPICAL ARRANGEMENT OF GAS AND WATER CONTAINERS FOR PRE-ENGINEERED SYSTEMS

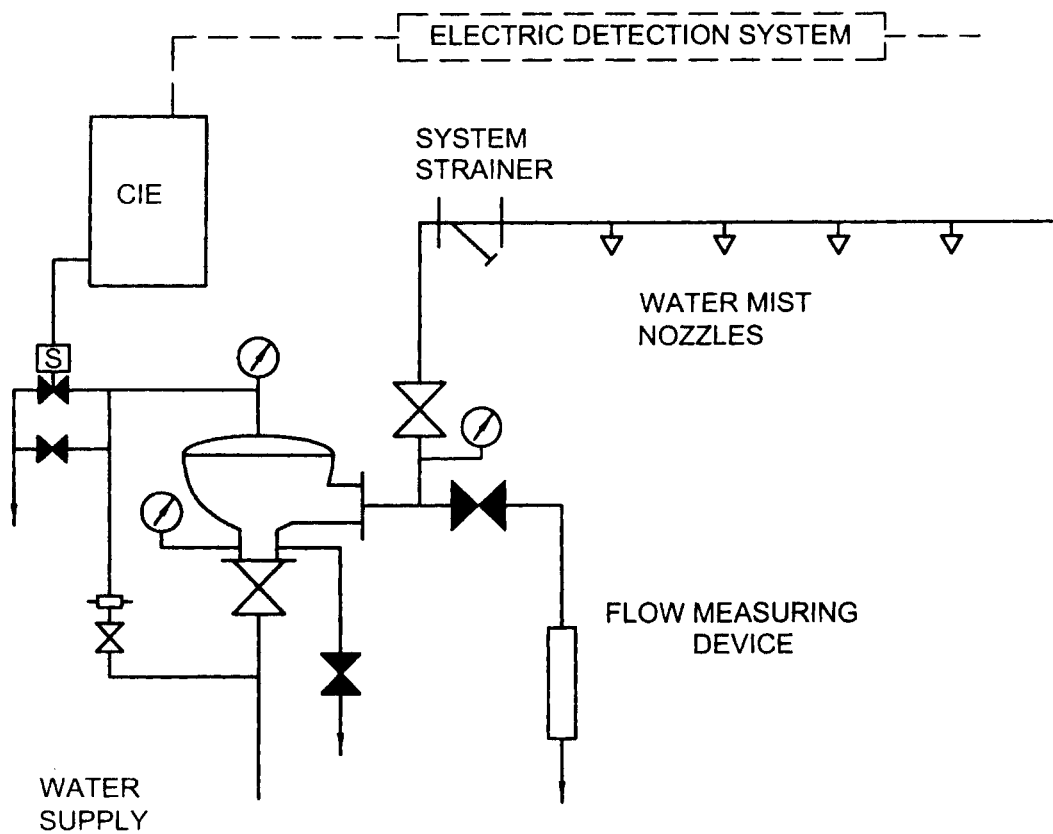


FIG. 3 TYPICAL CONTROL ASSEMBLY FOR WATER MIST DELUGE SYSTEM

3.10.9 Zoned Application System

A system designed to protect hazards in a predetermined portion of an enclosure.

4 DEFINITIONS

For the purpose of this standard, the definitions given below shall apply.

4.1 Atomizing Media — Compressed air or nitrogen that produce water mist by mechanical mixing with water.

4.2 Automatic — Performing a function without the necessity of human intervention.

4.3 Containers — A cylinder or other vessel used to store liquids or gases.

4.4 Container Discharge Valve — A valve directly connected to a container which, when actuated, releases extinguishing agent into the distribution piping.

4.5 Deep Seated Fire — A deep seated fire become established beneath the surface of a fibrous or particulate material. This may result from flaming combustion at the surface or from ignition within the mass of the fuel. Smoldering combustion may then progress slowly through the mass.

4.6 Density — System application rate, which may be expressed in the following two ways:

- a) Discharge density of the flow from the system in respect of the area of the risk and expressed as l/min/m².
- b) Flux density of the flow from the system in respect of the volume of the risk and expressed, in l/min/m³.

4.7 Directional Valve — A device for controlling the passage of the extinguishing agent from a supply manifold, directing it to pre-selected area(s) of protection.

4.8 Distribution System — All pipework and fittings downstream of any container valve, deluge valve or other control assembly.

4.9 D_{vf} — A drop diameter such that the cumulative volume, from zero diameter to this respective diameter, is the percentage of the corresponding sum of the total distribution.

NOTE — D_{v90} is the volume median diameter; that is, 90 percent of the total volume of liquid is in drops of smaller diameter and 10 percent is in drops of larger diameter.

4.10 Enclosure — The case, housing, partition or walls that will substantially contain water mist in the vicinity of the hazard for a sufficient length of

time to achieve the fire protection objectives.

4.11 Fire Control — The limitation of the growth of a fire by pre-wetting adjacent combustibles and controlling ceiling gas temperatures to prevent structural damage.

4.12 Fire Extinguishment — The complete suppression of a fire until there are no burning combustibles.

4.13 Fire Suppression — The sharp reduction of the rate of heat release of a fire and the prevention of regrowth.

4.14 Manual — Requiring human intervention to accomplish a function.

4.15 Monitoring — The supervision of the operating integrity of an electrical, mechanical, pneumatic or hydraulic control feature of a system.

4.16 Nominal Size (DN) — A numerical designation of size which is common to all components in a piping system other than components designated by outside diameters or by thread size. It is a convenient round number for reference purposes and is only loosely related to manufacturing dimensions.

4.17 Operating Device — Any component involved between actuation and release of extinguishment.

4.18 Water Mist — A water spray for which the Dv_{90} as measured at the coarsest part of the spray in a plane 1 m from the nozzle, at its minimum design operating pressure, is less than 1 000 μm .

4.19 Water Mist Nozzle — A special purpose device containing one or more orifices designed to produce and deliver water mist:

- a) *Sealed nozzle* — A nozzle that operates independently of other nozzles by means of a detection and activation device built into the nozzle.
- b) *Open nozzle* — A nozzle that contains open orifices suitable to connect distribution pipe network to discharge the water or fluid flow through the pipe.
- c) *Hybrid nozzle* — A nozzle that operates using a combination of the two methods in (a) and (b). A hybrid nozzle contains a built-in detection and activation device which can be activated by independent detection means.

5 OBJECTIVES

5.1 The objective of this standard is the protection of life and property from the consequences of fire, through standardization of design, installation and commissioning of water-based fire protection

systems that use water mist as the extinguishing agent.

5.2 The performance objectives of a water mist system shall be described using the following terms:

- a) *Fire control* — Fire control, which can be defined by one or more of the following:
 - 1) A reduction in the thermal exposure to the structure where the primary objective is to maintain the structure's integrity of the building (for example, to prevent flashover).
 - 2) A reduction in the threat to occupants where the primary objective is to minimize the loss of life.
 - 3) A reduction in a fire related characteristic such as a heat release rate, fire growth rate or spread to adjacent objects dilution of smoke and flammable vapour.
- b) *Fire suppression* — Fire suppression, which is the sharp reduction in the heat release rate of a fire and the prevention of its regrowth by a sufficient application of water mist.
- c) *Fire extinguishment* — Fire extinguishment, which is the complete suppression of a fire until there are no burning combustibles.

5.3 Applications

5.3.1 Water mist systems are used for a wide range of performance objectives, including the following:

- a) Fire extinguishment,
- b) Fire suppression,
- c) Fire control,
- d) Temperature control, and
- e) Exposure protection.

5.3.2 Typical uses for the systems are as follows:

- a) Rooms, vaults, enclosed machines, containers, storage tanks and bins.
- b) Flammable liquid storage and processing areas.
- c) Engines using flammable fuels.
- d) Computers, data processing equipment and control rooms.
- e) Electrical hazards, such as transformers, switches, circuit breakers, and rotating equipment.
- f) Electronic equipment, including telecommunication equipments.
- g) Cooking equipment using cooking oils and fats.

h) Ship engine bay.

j) Aircraft cargo bay, crew and cabin compartment.

5.3.3 A system may be used to protect more than one risk area by means of directional valves. Where two or more areas could be simultaneously involved in a fire by reason of their proximity, such areas shall be protected by either:

- a) Individual systems designed to allow simultaneous operation; or
- b) A single system sized and arranged to discharge simultaneously on all potentially involved hazards.

5.4 Limitations of Water Mist Systems

5.4.1 The systems shall not be used for direct application to materials that react with water to produce significant amounts of heat or hazardous products. These materials include the following:

- a) Reactive metals, such as lithium, sodium, potassium, magnesium, titanium, zirconium, uranium and plutonium, etc;
- b) Metal alkoxides, such as sodium methoxide;
- c) Metal amides, such as sodium amide;
- d) Carbides, such as calcium carbide;
- e) Halides, such as benzoyl chloride and aluminium chloride;
- f) Hydrides, such as lithium aluminium hydride;
- g) Oxyhalides, such as phosphorus oxybromide;
- h) Silanes, such as trichloromethylsilane;
- j) Sulfides, such as phosphorus pentasulfide; and
- k) Cyanates, such as methylisocyanate.

5.4.2 Systems shall not be used for direct application to liquefied gases at cryogenic temperatures (such as liquefied natural gas) which boil violently when heated by water.

5.5 Environmental Factors

When selecting a system to protect a risk, the effects of water run-off on the environment shall be considered.

5.6 Approval and Testings

5.6.1 Any water mist system that has been tested and approved by a recognized test and approval body shall be deemed to satisfy the requirements of this standard.

5.6.2 There is nothing in this standard to restrict new technologies that provides better level of safety.

6 SAFETY REQUIREMENTS

6.1 Hazards to Personnel

For fire situations, suitable safeguards shall be provided to ensure prompt evacuation of and to prevent entry into hazardous atmospheres and also to provide means for prompt rescue of any trapped personnel. Safety items such as personnel training, warning signs, discharge alarms, self-contained breathing apparatus, evacuation plans, and fire drills shall be considered.

6.2 Electrical Clearances

The clearance is the air distance between water mist system equipment, including piping and nozzles, and unenclosed or uninsulated live electrical components at other than ground potential. The minimum clearances provided are for the purpose of electrical clearance under normal conditions; they are not intended for use as safe distances during water mist system operation.

6.2.1 All system components shall be located to minimum clearances from unenclosed and uninsulated energized electrical components in accordance with SP 30.

NOTE — In risk that contain live electrical equipment and where the presence of free water or water mist may create conditions hazardous to personnel, consideration should be given to the evacuation of the area or the shutting down of electrical equipment prior to the discharge of water mist.

6.3 General Requirements

In areas protected by a water mist system, which are capable of being occupied, the following safety requirements shall be provided:

- a) Lighting and adequate direction signs for safe evacuation,
- b) Pre-discharge, visible and audible alarms, and
- c) Warning and instruction signs.

6.4 Water Quality

6.4.1 Water mist system with additives protecting normally occupied areas shall incorporate a manual lock off valve unless the additive in the concentration used has been evaluated as safe for human exposure by an appropriate authority. The valve, where fitted, shall be locked whenever the protected area is occupied.

6.4.2 Water mist systems using potable water or natural sea water are not considered to present a toxicological or physical hazard and are safe for use in occupied areas.

7 SYSTEM DESIGN

7.1 General

A system shall be designed and installed in accordance with its application for the specific hazards and performance objectives. Compliance with the above shall address compartment geometry, fire hazard, and system variables.

7.2 Enclosure Variables

Floor area, enclosure volume, ceiling height, ventilation conditions and the like, shall be considered when designing a system in regard to nozzle location, system flow rate and the total water usage of the system.

7.3 Nozzles

7.3.1 Nozzles shall be installed in accordance with manufacturer's instructions. The minimum and maximum nozzle height limitations, nozzle spacing limitations, distance from walls, obstructions to nozzle discharge, distance below ceilings, spacing under pitched or curved surfaces shall be in accordance with manufacturer's instructions.

7.3.2 Nozzles subject to mechanical damage shall be protected with approved guards. Guards shall not significantly reduce the effectiveness of the nozzle.

7.3.3 Escutcheon plates used in a recessed or flush-type nozzle installation shall be a part of approved nozzle assembly.

7.3.4 Ordinary temperature-rated nozzles shall be used unless otherwise specified.

7.4 Ventilation

7.4.1 General

Ventilation considerations shall include both natural and forced ventilation parameters.

7.4.2 Natural Ventilation

The number, size and location of the openings in the space (for example, the door, window) shall be addressed in the design and installation of the system. In some cases, special precautions are necessary to minimize the effects of these openings. These precautions include, but are not limited to, automatic door closures and water mist curtains.

7.4.3 Forced Ventilation

The effect of the air-handling system in the protected area shall be considered in the design and installation. The system shall shut down prior to system activation, however, if it can be demonstrated

that the air-handling system is not detrimental to the performance of the water mist system or has been compensated for, it may continue to operate.

NOTE — Natural ventilation or openings in the enclosure allow the hot gases to exhaust mist from the enclosure, decreasing the system's extinguishing potential. The flow of gases in or out of the enclosure, or when air-handling equipment is left running, can affect the mixing characteristics of the system and may require additional water mist nozzles to compensate for such conditions. Prior to, or simultaneously with, the discharge of the system, provision should be made for the closing of doors and dampers and the shutdown of electrical equipment.

7.5 Hazard Analysis

A fire hazard analysis shall be conducted to determine both the design of the system and the type of detection and activation methods required. The system shall be assessed on the fuel type, fire loading and anticipated fire growth. The case of ignition or re-ignition of the fuel, the fire growth rate and the ability to achieve extinguishment shall be considered when selecting or designing a system.

7.6 Fire Hazard Classification

The fire hazard shall be classified by both the combustible loading and fuel type.

7.6.1 Combustible Loading

A fire hazard analysis shall be conducted to determine both the design parameters of the water mist system and the type of detection/activation scheme employed by the system. The system shall be based on the fuel type, combustible loading and anticipated fire growth rate as well as the desired fire fighting performance objectives.

7.6.2 Fuel Type

Overall fire hazard is directly related to the type and quantity of the fuel present in a space. The ease of ignition/reignition of the fuel, the fire growth rate and the difficulty of achieving control, suppression, extinguishment or any combination thereof, shall be considered when selecting or designing a water mist system.

7.6.2.1 Class A fires

Fuel loading and configuration shall be considered when selecting/designing a system to protect a space or area containing Class A materials. If fire extinguishment is desired, consideration shall be given to the potential for deep-seated fires as well as to the potential for smoldering fires.

7.6.2.2 Class B fires

The hazard associated with Class B fires is related

primarily to the fuel loading, fuel configuration, flashpoint and burning rate of the fuel. Preburn time also affects the overall characteristics of the fire. Class B fires are grouped into two categories — Two-dimensional pool fires and three-dimensional spray and running fuel fires. The parameters associated with each category are as follows:

- a) Class B Two-dimensional fires:
 - 1) Fuel loading and configuration,
 - 2) Fuel flashpoint, and
 - 3) Preburn time pool/spill size.
- b) Class B Three-dimensional fire:
 - 1) Fuel loading and configuration,
 - 2) Fuel flashpoint,
 - 3) Preburn time,
 - 4) Cascade/running fuel fires,
 - 5) Fuel flow rate,
 - 6) Fire configuration,
 - 7) Spray fires,
 - 8) Fuel line pressure,
 - 9) Fuel spray angle,
 - 10) Fuel spray orientation, and
 - 11) Reignition.

7.6.2.3 Class C fires

Electrical conductivity of water and water mist shall be addressed when considering applications where the primary fire is a Class C fire.

7.6.2.4 Combination fires

Combination in fuel loadings and hazards shall be addressed.

7.7 Documentation

All documentation shall be done in accordance with IS 15493.

7.7.1 System Calculations

Except for pre-engineered systems, hydraulic and pneumatic calculations shall be carried out as per 16. Calculations shall be provided, including a summary of calculations and shall be referenced to a drawing showing the location of reference nodes in the system.

7.7.2 Design Approval

All documentation shall be submitted to the appropriate authority for approval before the commencement of work.

When field conditions necessitate any material

change from approved documentation, the change shall be submitted for approval.

7.8 The water supply for a system can be either limited or unlimited and shall comply with the requirements of **9**.

7.9 Components

System components shall be suitable for the pressures and environment imposed on them and shall comply with the relevant Indian Standard or shall be listed as suitable for the intended application, and shall comply with **12**.

7.10 Extinguishing Agent

The extinguishing agent, propellant or pressurizing gas and any other additives, shall be compatible with each other and the materials used in the construction of the system.

7.11 Additives

Additives may be used in water mist systems to achieve a number of diverse objectives, including the following:

- a) Improved fire suppression or extinguishing ability,
- b) Application of mist to water soluble fuels,
- c) Protection of the system against freezing, and
- d) Prevention of bacterial contamination.

7.11.1 Limitations

The employment of additives in water mist systems imposes limitations. Any system incorporating an additive shall:

- a) be tested with that specific additive, additive concentration and its method of introduction;
- b) be clearly identified by means of container labels and warning signs as a system using additives; and
- c) be calculated by means other than IS 2952 (Part 2) / IS 4477 (Part 2), unless it can be shown that the additive has negligible effect on the flow characteristics of water, such as density and viscosity.

7.12 Control Systems

Control and activation systems shall comply with the relevant Indian Standard and the requirements of **13**.

7.13 Marine Systems

Systems designed for marine use shall comply with the requirements of **14** and the relevant Marine Orders issued by SOLAS & IMO.

7.14 Acceptance of Installation

Before the completed installation is approved, it shall be tested for compliance with **15**. After testing acceptable to the appropriate authority, as-installed documentation including drawings and operation and maintenance manuals shall be provided.

8 PROTECTED HAZARD REQUIREMENTS

8.1 Unclosable Openings

For certain systems a well-enclosed and sealed space is preferred. Particular attention should be given to openings around cables and duct entries into the space, return air louvers, and the like.

9 WATER SUPPLIES

9.1 General

Water supplies for system shall be either one or both of the following:

- a) *Unlimited water supply* — through main connection, natural sea water suction line, reservoir or tank
- b) *Limited water supply* — from stored pressure water container connected to external gas pressure supply.

Water supplies shall satisfy the maximum system demand at the approved rate of discharge for a period of not less than 10 min.

9.2 Unlimited Water Supply

Unlimited water supply shall satisfy the maximum system demand at a listed rate for a period not less than 90 min.

A filter or strainer shall be provided at each water supply connection. The filter or strainer shall be installed downstream of all piping that is not corrosion resistant. Such strainer shall be provided with a clean-out port and shall be arranged to facilitate inspection, maintenance and replacement.

Water supply pumps supplying water to mist system shall be of sufficient capacity to meet the system demand and requirements of the approval.

Pumps, pump controls and valves shall be located as close as possible to the hazard or hazards they protect; however they shall be located outside the risk.

9.3 Limited Water Supply

Except in the case of pre-engineered systems arranged for two complete discharges in accordance with their approval conditions, limited water supplies shall satisfy the maximum system demand

for not less than 30 min. Limited water supply containers applicable to this standard are as follows:

- a) Water supply container with a separate gas container,
- b) Stored pressure type with inert gas or air stored under pressure in a container having a maximum fill ratio as per the approval, and
- c) Tank(s) and pump(s).

A reserve supply of water and atomizing or pressurizing gas shall be provided where the extinguishing agent can not otherwise be replaced within 24 h following system operation or if a single water supply is used for multiple risks. If a manual changeover is necessary, the mechanism shall be readily accessible from outside of the risk. Means shall be provided to prevent discharge of reserve supplies from open manifold connections when supplies are removed for servicing. The reserve quantities shall be identical to the initial supply.

10 PRESSURIZED STORAGE CONTAINER ARRANGEMENT

The arrangement of pressurized storage containers and accessories for either water or gas, shall be as follows:

- a) Containers and accessories shall be located and arranged so that inspection, testing, recharging and other maintenance are facilitated, and interruption to protection is kept to a minimum.
- b) Containers should be located outside of, and as near as practicable to, the risk. Containers protecting a single risk can be located within the protected area they serve only if sited to minimize the risk of exposure to fire and explosion.

NOTE — Storage temperature should not exceed 55°C nor be less than 0°C, unless the system is designed for operation in storage temperatures outside this range. External heating or cooling may be used to keep the temperature within the desired range.

- c) Containers shall be so located that they are not subject to severe weather conditions or to mechanical, chemical or other damage. Where excessive climatic or mechanical exposures are expected, suitable guards or enclosures shall be provided.
- d) Reliable means shall be provided to indicate the pressure in refillable, pressurized gas containers.

11 AUTOMIZING GAS FOR TWIN FLUID SYSTEMS

Atomizing gas essential to the generation of water mist shall be taken from a dedicated source and shall comply with the following:

- a) Atomizing gas shall be supervised for high and low pressure.
- b) Regulators controlling the supply of water and atomizing gas shall be listed for the intended purpose.
- c) A check valve or other means shall be installed in the piping at the supply point to every nozzle to prevent the entrance of water into the atomizing gas.
- d) Filters or other means to protect nozzles from obstructions shall be provided.
- e) Where used, air compressors shall be a dedicated source and shall be listed for use on fire protection systems.
- f) Electrically driven compressors used as a dedicated supply shall be connected to the line side of the main switch.

12 COMPONENTS AND INSTALLATION

12.1 General

System components including pipe, tube and fittings referred to in this clause shall be suitable for the pressures, temperatures and environment imposed on them. They shall comply with the relevant Indian Standard.

NOTE — For the purpose of this standard pipe also implies tube.

12.2 Valves

12.2.1 General

All valves on a system pipework utilizing stored pressure containers shall be rated at not less than the maximum container pressure at 55°C.

12.2.2 Isolating Valves

There shall be no isolating valve between a container and the discharge nozzles other than the container discharge valve, directional valves, manual lock-off valves where fitted or valves required for flow testing.

12.2.3 Valve Monitoring

Any normally closed or open valve in the waterway shall be monitored or locked in its operating position.

12.2.4 Valve Protection

All installed valves shall be protected against mechanical, chemical or other damage. In addition, container discharge valves shall be protected against impact damage during transit. Protection may be provided by valve protection rings, transit caps, or by employing impact-resistant valves.

12.3 Pipework

12.3.1 Piping

All system pipe work shall be constructed of Class A pipe complying with relevant Indian Standard unless otherwise permitted. Installation piping downstream of the system strainer shall be of corrosion-resistant material such as copper, stainless steel or hot-dipped galvanized steel to relevant Indian Standard.

12.3.2 Flexible Connections

Flexible connections used anywhere in the system shall be deemed non-combustible when tested in accordance with relevant Indian Standard, and shall be rated for at least the maximum expected pressure at 65°C.

12.3.3 Pipe or Tube Bending

Bending of pipe or tube shall be permitted, provided bends are made without kinks, ripples, distortions, reductions in diameter, or any noticeable deviations from a round shape. The minimum radius of a bend shall be in accordance with the manufacturer's specifications.

12.3.4 Pipe Threads

All threads used in system piping shall conform to the requirements of relevant Indian Standard. Joint sealing tape, compounds or thread lubricants, shall be applied only to the male thread.

12.3.5 Fittings

All fittings on system piping shall be suitable for the maximum subjected pressure. Fittings downstream of the strainer shall be of corrosion-resistant material such as copper, stainless steel or hot-dipped galvanized steel to relevant Indian Standard.

12.3.6 Flanges

Where used, flanges shall conform with the requirements of relevant Indian Standard.

12.3.7 Welding and Brazing

Welding and brazing shall conform with the

requirements of relevant Indian Standard and filler materials used in brazing shall have a melting point in excess of 535°C. Welding or brazing fluid residue shall be removed prior to installation.

12.4 Installation of Pipework

12.4.1 Preparation of Pipe

Each pipe or section of pipework shall be cleaned after preparation and before assembly. The pipework shall be free of particulate matter and oil residue before the installation of nozzles or discharge devices.

NOTE — When installing pipework, care should be taken to avoid possible restrictions due to foreign matter, faulty fabrication or improper installation. Pipe ends should be reamed after cutting.

12.4.2 Pipe Supports

Piping shall be securely supported and allowance shall be made for thrust forces, expansion and contraction. It shall be designed to withstand likely vibration and mechanical, chemical or other damage. Where there is the possibility of explosion, the piping shall be attached to supports that are least likely to be displaced. In all other respects hangers shall comply with the requirements of relevant Indian Standard.

12.4.3 Distance Between Supports

The maximum distance between supports shall take into account the total mass of the pipe and contents. The distance between supports shall be in accordance with Table 1.

12.5 Drain Valves

Where used, drain valves shall be fitted at the lowest points in the pipework of dry systems.

12.6 Dirt Traps

Where a system employs thread sealing materials such as tape or has welded or brazed joints, dirt traps shall be provided. Dirt traps shall consist of a tee with a capped dirt-leg at least 50 mm long.

12.7 All system piping and fittings shall be installed so that the entire system can be drained.

12.8 Discharge Nozzles

12.8.1 Corrosion Protection

Nozzles used in corrosive atmospheres shall have a coating or shall be manufactured from corrosion-resistant material. Where a coating is used, it shall be applied by the nozzle manufacturer and the coated nozzle shall be approved.

Table 1 Maximum Spacing of Pipe Supports
(Clause 12.4.3)

Sl No.	Nominal Pipe Size (DN)	Maximum Spacing of Brackets and Clips	
		Copper and Light Wall Steel	Galvanized Steel and Stainless Steel m
(1)	(2)	(3)	(4)
i)	6	0.25	0.50
ii)	10	0.50	1.00
iii)	15	1.00	1.50
iv)	20	1.50	4.00
v)	22	—	—
vi)	25	2.00	4.00
vii)	32	2.50	5.00
viii)	40	2.50	5.00
ix)	50	3.00	5.00
x)	63	—	—
xi)	65	3.00	5.00
xii)	75	—	—
xiii)	80	4.00	5.00
xiv)	90	4.00	5.00
xv)	100	4.00	5.00
xvi)	110	—	—
xvii)	125	4.00	6.00
xviii)	140	—	—
xix)	150	4.00	6.00

12.8.2 Nozzle Clogging

Where external clogging is likely, discharge nozzles shall be provided with frangible discs, blow-off caps or other suitable devices. These devices shall provide an unobstructed opening upon system operation and shall be arranged so they cannot injure personnel.

12.8.3 Spare Nozzles

Where sealed thermally activated nozzles are installed in a system, a stock of minimum 10 percent spare nozzles or thermal activators, shall be provided and housed in a suitable cabinet.

12.9 Strainers

Line strainers or filters shall have a clean-out port preferably with replacement strainer or filter elements. Filters or strainers without replaceable elements may only be used if they are included as a component of a listed system. Such filters or strainers shall be installed with demountable joints to facilitate the removal and replacement of the complete unit. The maximum filter or strainer mesh opening shall be 80 percent of the minimum nozzle waterway dimension. Strainers and

filters shall be installed and arranged to facilitate inspection, maintenance and replacement.

NOTE — Nozzles with multiple orifices and with minimum waterway dimensions greater than 800 µm per opening shall not be required to be provided with a strainer or filter at each nozzle.

12.10 Compressed Gas Pressure Regulating Valve (PRV)

PRVs shall be installed in accordance with the manufacturer's recommendations, PRVs shall be installed when the supply pressure is higher than the design operating pressure of the water mist system. PRVs shall be capable of providing a stable regulated output at the rated flow capacity and design setting, over the full range of input pressures that will be experienced over the course of the discharge period.

Downstream pressure creep under no-flow conditions shall not exceed the lesser of the downstream components pressure rating or the pressure relief valve set point, if provided. Pressure set, point-adjusting mechanisms on the PRVs shall be tamper resistant and the adjustment shall be indicated by a permanent marking. A means to indicate evidence of tampering shall be provided. The PRVs set point shall be set by the manufacturer. Permanent markings shall indicate the inlet and outlet connections of the PRVs.

12.11 Check Valves

Check valves shall be installed in the main feed lines, near the control valves of both the water and pneumatic system piping of a twin fluid system, to prevent the backflow of water or atomizing fluid into the companion piping. A check valve shall be installed between the system and the point of permanent connection to a potable water supply. Check valves shall be installed in accordance with the manufacturer's listing.

12.12 Pressure Indication

12.12.1 General

A pressure-indicating device shall be fitted to each pressurized water container or gas cylinder and shall indicate whether the container is charged to its nominal operating pressure or is undercharged or overcharged. The device shall be clearly visible and legible when the container is mounted in its service position unless the location of the pressure-indicating device is identified.

The minimum range of the pressure indicator should be 1.5 times the working pressure of the system. The accuracy of the indicator shall be 10 percent of the nominal system working pressure.

The pressure indicator shall indicate the operable pressure range of the system in contrasting colour to the remainder of the indicator face. The working pressure shall be shown in numerals.

12.12.2 Pressure Gauges

Where a pressure gauge is used, it shall comply with IS 3624 and have a dial face not less than 75 mm in diameter and a full scale reading at least 130 percent of the maximum pressure expected at the point of connection. Where applicable, pressure gauges shall be installed in the following locations:

- a) On both sides of a pressure regulating valve,
- b) On the pressurized side of all supply connections,
- c) On the pressurized side of all system control valves, and
- d) On all air supplies for dry-pipe and pre-action systems.

12.13 Storage Containers

12.13.1 Gas Cylinders

Gas cylinders used for the storage and transportation of gas at high pressures shall conform with the requirements of IS 7285 and IS 8198.

12.13.2 Pressurized Containers

Containers used for water storage that are normally pressurized, or that are pressurized when the system is activated, shall conform with the requirements of relevant Indian Standard.

12.13.3 Pump Suction Tanks

Where pump suction tanks are used as the water supply for a system, they shall be constructed from concrete or steel.

13 CONTROL SYSTEMS

13.1 General

Control and actuation systems shall be electrical, pneumatic, mechanical, or any combination of these. Such systems shall be either manual only or automatic with manual override in accordance with IS 15493.

13.2 Operating Devices

Operating devices, such as storage container discharge valves, isolation and discharge controls and ancillaries shall incorporate manual reset facilities.

Operation of any container release device shall cause operation of all containers required for that particular risk.

All devices shall be located, installed and suitably protected so that they are not subject to mechanical, chemical or other damage which may impede their correct operation.

13.3 Control and Indicating Equipment

Automatic electrically controlled extinguishing agent extinguishant discharge systems, shall incorporate control and indicating equipment complying with relevant Indian Standard.

A system is solely designed for manual operation, the control and indicating equipment shall comply with the system listing.

13.4 Audible Alarms and Visible Warning Devices

Audible alarms and visible warning devices shall be provided as follows:

- a) *Fire alarm* — In systems that require more than one detector to operate before the extinguishing agent is discharged, a visible indication appropriate to the risk shall light and the alert tone, shall sound immediately upon receipt of any alarm.
- b) *Do not enter and evacuate* — Where it is required that the protected area be evacuated before system discharge, the initiation of the discharge sequence shall cause these visual devices to illuminate and activate the audible 'evacuate' tone continue after extinguishant discharge until the risk is made safe.
- c) *System inoperative* — Any condition that inhibits the automatic discharge of the system shall cause this visual indicator to illuminate and the conditions shall include but not be limited to the following:
 - 1) Operation of maintenance isolation switch.
 - 2) Fault in actuation system.
 - 3) Operation of lock-off valve (where fitted).
 - 4) Operation of manual inhibit switch (where fitted).
 - 5) Isolation or fault on any part of the fire detection system.

13.5 Mechanical Release

13.5.1 Automatic

Automatic mechanical release systems shall employ suitable means such as cables and where required, drop weights. The control cables shall be run within protective tubes with free-turning corner pulleys at all changes of direction.

Mechanical control shall be capable of being tested periodically for proper operation. Where fusible links are used, they shall conform to relevant Indian Standard.

13.5.2 *Manual*

Manual mechanical release shall be protected from accidental operation. The release shall require a push or pull of not more than 110 N and a movement of not more than 150 mm, to ensure operation.

NOTE — Where required, a warning sign complying shall be displayed.

13.6 **Pneumatic Release**

13.6.1 *General*

Release systems may be operated pneumatically by gas pressure from a stored or continuous source. Alternatively, release systems may be operated directly from gas-pressure-generating heat detection systems. All pneumatic systems shall be capable of being tested periodically for proper operation.

13.6.2 *Energy Source*

In the case of systems using stored pressure water containers, gas pressure from the storage containers may be used as a source of energy for system release. Alternatively, pressure from separate pilot gas containers may be used.

Where gas pressure from pilot containers is used for the release of multiple water containers, the pilot gas quantity and flow rate shall be adequate to release simultaneously all of the containers for that risk.

13.6.3 *Reliability of Energy Source*

Pilot gas containers that are not fitted with a pressure indicating device shall be duplicated.

The pilot gas shall be used solely for actuating the system.

14 **COMMISSIONING AND ACCEPTANCE TESTING**

14.1 **Test and Acceptance**

Test for all systems shall comply with the following:

- a) Tests shall be conducted as part of the nozzle or system to address the compartment geometry, fire hazard, and performance objectives, of the application specified.
- b) Tests shall be designed to replicate most or all of the application parameters associated with a given installation and any variations

in these parameters shall be substituted using the worst-case conditions. The listing of the system hardware shall be consistent with the intended system application.

- c) Tests shall be designed and conducted to stress the system in order to determine the working limits and parameters of the system and to incorporate adequate severity to minimize the effects of test parameter variations.

The results of the test shall be documented. The documentation shall identify the working limits and parameters of the system, the fire hazard and the range of compartment parameters.

14.2 The results of the investigation should identify but not be limited to the following:

- a) Fire protection objectives of the system (that is control, suppression or extinguishment) type of application (that is total flooding, zoned or local application), classes and types of fire (pool, running and spray) and types of fuel.
- b) The protected enclosure volume limitations, allowable openings and ventilation conditions.
- c) The maximum and minimum system flow rates, that is, the flow rate per unit volume or the flow rate per unit area as applicable to the specific risk.
- d) The maximum and minimum system operating pressure, the nozzle operating range, the pump or cylinder operating pressure range, as applicable and the pump inlet and outlet pressure and flow requirements.
- e) Quality, temperature, quantity and duration of the water supply.
- f) Nozzle performance characteristics including spray angle, droplet size and distribution, momentum and velocity.
- g) Nozzle installation requirements including the maximum and minimum distances above the floor of the hazard and below the ceiling, nozzle spacing, orientation, minimum distance from walls and obstructions or shielding.
- h) Activation device type or model number.
- k) Specification of the distribution system and pump or storage cylinder.

14.3 **Criteria for Acceptance**

The completed water mist system shall be commissioned in accordance with Annex B and the

system's performance shall be proven by the following methods:

- a) All pipework that could potentially contain water shall be hydrostatically tested to 1.5 times the normal working pressure for 2 h. Any loss shall be determined by a drop in gauge pressure or visible leakage.
- b) The water mist system shall be tested as follows:
 - 1) It shall be subjected to full discharge test and the system and supply pressure shall be recorded.
 - or
 - 2) Where a full discharge test is not required by the appropriate authority, provision shall be made to verify the pressure and flow of the water supply and free passage to all nozzles.

On completion of the acceptance procedure, a certificate of compliance shall be issued by the installation contractor.

14.4 Failure

Where the system fails to comply with 14.2, the fault shall be rectified and, if necessary, the system retested.

14.5 Approval of Water Mist Systems

The completed system shall be reviewed and tested by qualified personnel to meet the approval of the appropriate authority. These personnel shall confirm that approved equipment and devices have been used in the system where required by this Standard. To determine that the system has been properly installed and functions as specified, the installing contractor shall:

- a) notify the regulatory authority and the owner's representative of the time and date of testing is to be performed; and
- b) perform all required acceptance tests.

Where practicable, full flow tests of the system piping, using water, should be made as a means of checking the nozzle layout, discharge patterns and any obstructions, determining the relationship between design criteria and actual performance and ensuring against the clogging of the smaller piping and nozzles by foreign matter carried by the water.

Where practicable, the maximum number of systems that are expected to operate in case of fire should be in full operation simultaneously when checking the adequacy and condition of the water supply.

All operating parts of the system should be tested fully to ensure that they function as intended. The proper function and sequence of all devices should be verified.

After flow testing, all filters and strainers should be inspected and cleaned or replaced, as necessary.

14.6 Leak Tests

All pipework normally charged with air or gas under pressure shall be subjected to gas leakage test conducted for 10 min at not less than 200 kPa. Any leakage during this period, which results in a loss of pressure in excess of 10 percent of the test pressure, shall be corrected.

14.7 When cold weather does not allow testing with water, an interim air test shall be conducted as given in 14.7.1.

14.7.1 Intermediate and High Pressure Systems

All interior piping and attached appurtenances subjected to system pressure shall be hydrostatically tested to 150 percent of the normal working pressure, and they shall maintain that pressure without loss for 2 h. Loss shall be determined by a drop in gauge pressure or visible leakage.

14.7.2 Air Tests

For dry and preaction systems, an air pressure leakage test at 40 psi (0.28 MPa) shall be conducted for 24 h in addition to the standard hydrostatic test. Any leakage that results in a loss of pressure in excess of 1½ psi (0.01 MPa) during the 24 h shall be corrected.

14.8 Pneumatic Pressure Testing Warning

Prior to conducting that pneumatic pressure test, the protected area shall be evacuated and appropriate safeguards provided for test personnel.

The following warning sign shall be prominently displayed to draw attention to personnel that hazards may be associated with pneumatic pressure testing.

WARNING

‘DANGER DO NOT ENTER
PNEUMATIC PRESSURE TEST
IN PROGRESS’

NOTE — Pneumatic pressure testing creates a potential risk of injury to personnel in the area as a result of airborne projectiles if rupture of the piping system occurs.

15 HYDRAULIC CALCULATIONS

15.1 General

All systems shall be designed using full hydraulic analysis procedures, to ensure that nozzle performance

is within the required parameters as specified in their listing documents.

Systems by their very nature depend on clearly defined pressure limits that are required to be maintained at the nozzles. Therefore, close attention should be paid to the hydraulic calculations to achieve satisfactory results.

15.2 System Calculations

Except for pre-engineered systems, hydraulic and pneumatic calculations shall be carried out using the methods described in 12. Calculations shall be provided, including a summary of calculations and shall be referenced to a drawing showing the location of reference nodes in the system.

16 MARKING

16.1 Identification and Marking of Containers

16.1.1 Identification

Each container shall be identified in accordance with the Indian Standard relevant to its contents.

16.1.2 Permanent Markings

Each container shall be permanently marked in accordance with relevant Indian Standard.

16.1.3 Markings

The following information shall be displayed on all the equipments by means of painting or embossing:

- a) System manufacturer’s name or trade-mark.
- b) Name or chemical description of gas.
- c) Pump and pressure gauges, valve, etc.
- d) Specific hazards and protection objectives.
- e) Volumetric flow rate characteristics of water discharge for each nozzle.
- f) Maximum height of protected space.
- g) Minimum distance between nozzle tip or diffuser, as applicable, and plane of protection.
- h) Minimum spacing between nozzles.
- j) Maximum coverage area per nozzle.
- k) Maximum coverage area from wall.
- m) Minimum and maximum rated operating pressure of nozzle.
- n) Allowable range of nozzle orientation angle from vertically down.
- p) Maximum time delay for water mist delivery to the most remote nozzle.

ANNEX A
(Clause 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	Title	IS No.	Title
2952 (Part 2) : 1965	Recommendations for methods of measurement of liquid flow by means of orifice plates and nozzles: Part 2 Compressible fluids	7285 : 1988	Specification for seamless steel cylinders for permanent and high pressure liquefiable gases (second revision)
3624 : 1987	Specification for pressure and vacuum gauges (second revision)	8198 : 1984	Code of practice for steel cylinders for compressed gases
4477 (Part 2) : 1975	Methods of measurement of fluid flow by means of venturi meters: Part 2 Compressible fluids	15493 : 2004	Gaseous fire extinguishing systems — General requirements
		SP 30 : 1985	National Electrical Code

ANNEX B
(Clause 14.3)

COMMISSIONING CHECK LIST

<i>Sl No.</i>	<i>Visual Inspection</i>	<i>Clause Reference</i>	<i>Compliance Verified</i>	<i>Type of Test Carried Out, If Applicable</i>	<i>Remarks</i>
(1)	(2)	(3)	(4)	(5)	(6)
i)	Do the plans accurately illustrate the hazard configuration?	7.7			
ii)	Are all components of the system in compliance with this Standard?	7.9			
iii)	Check all flow calculations and verify that the containers, piping and operational equipment are installed and sized in accordance with the plans	7.7, 9, 12 and 15			
iv)	Are dimensions of unclosable openings in accordance with the plans?	7.7 and 8.1			
v)	Check protected area for openings other than those in (iv) above	7.7 and 9			
vi)	Does the nameplate data on storage containers correlate with the submitted details?	16.1.3			
vii)	Check quantity and mass of containers	10			
viii)	Check protected area volume	8			
ix)	Check need for and adequate provisions of post-fire ventilation	6			
x)	Physically check the pipework. Are pipe joints sound and is pipework adequately secured?	12.4			
xi)	Ensure that storage containers are disconnected	—			
xii)	Perform a full functional check of system (by operation of detectors) noting correct auxiliary electrical shutdown function (for example, ...) doors released, dampers shut, air-handlers shutdown, etc (see Note 1)	7.4, 8 and 13			
xiii)	Ensure that any non-fire shutdown plant capable of affecting system performance is operating during the test	7.4			

<i>Sl No.</i>	<i>Visual Inspection</i>	<i>Clause Reference</i>	<i>Compliance Verified</i>	<i>Type of Test Carried Out, If Applicable</i>	<i>Remarks</i>
(1)	(2)	(3)	(4)	(5)	(6)
xiv)	Ensure system release(s) operates correctly (<i>see</i> Note 2)	13			
xv)	Activate each detector head or system in turn by employing heat, products of combustion, etc. Ensure each manual alarm point operates and transmits	—			
xvi)	Ensure that the detection and control equipment complies with configuration and operation	13			
xvii)	Ensure that visual and audible alarms operate	13.4			
xviii)	Ensure that each alarm registers on CIE and mimic panels, if any	13.3			
xix)	Check that air-handling plant shut-down relay is activated	7.4 and 13.2	and		
xx)	Where multiple alarms are required for system operation, ensure that first and subsequent level alarms operate, including audible and visual indications, auxiliary equipment, and gas release mechanisms, if installed	13.4			
xxi)	Check that directional valves are fitted where required and ensure that they operate correctly	4.7, 5.4 and 12.2			
xxii)	Reset the system and check all manual release devices	—			
xxiii)	Reconnect storage container. Ensure that all caps, plugs and locking pins are removed and that the system is left in an operable condition (<i>see</i> Note 3)	14.5			

NOTES

- 1 The objective is to check that the entire system operates, while avoiding unwanted discharging of the system.
- 2 The objective is to determine that the system operation mechanism functions when required and does not function under any other circumstance.
- 3 This should always be the last commissioning function.

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This Indian Standard has been developed from Doc : No. CED 22 (7125).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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